Erwin Lichtenegger. The art of roots

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02
2023
SECONDA SERIE

Abstract

Over a period of approximately 50 years, scholars (Lore Kutschera, Erwin Lichtenegger, Monika Sabotik) from the research center of the Pflanzensoziologisches Institut in Klagenfurt have carried out excavation campaigns to study the roots of plants. The excavations, even deep ones, were aimed at understanding the morphology, shapes and adaptation capabilities that plants have developed through their roots in relation to climate conditions, temperatures and soil structure and the proximity of other species. The research gave rise to seven volumes with illustrations of the roots drawn up by Erwin Lichtenegger. The drawings, drawn by hand in pencil, represent, following measurements, the complexity of the root system according to a hypothetical section which however portrays the three-dimensional assembly of the part of the plant kept underground, making the invisible visible. The representations offered a specific scientific contribution in relation to the behavior of plants, but also the interpretation of reality through artistic drawing.

Nell'arco di circa 50 anni gli studiosi (Lore Kutschera, Erwin Lichtenegger, Monika Sabotik) del centro ricerche del Pflanzensoziologisches Institut di Klagenfurt hanno effettuato campagne di scavo per studiare le radici delle piante. Gli scavi, anche profondi, erano finalizzati a comprendere la morfologia, le forme e le capacità di adattamento che le piante hanno sviluppato attraverso le loro radici in relazione alle condizioni climatiche, alle temperature e alla struttura del suolo e alla vicinanza di altre specie. Dalla ricerca sono nati sette volumi con le illustrazioni delle radici redatti da Erwin Lichtenegger. I disegni, realizzati a mano a matita, rappresentano, seguendo misurazioni, la complessità dell'apparato radicale secondo un'ipotetica sezione che ritrae però l'assemblaggio tridimensionale della parte di pianta mantenuta interrata, rendendo visibile l'invisibile. Le rappresentazioni offrono un contributo scientifico specifico del comportamento delle piante ma anche interpretazione della realtà attraverso il disegno artistico.

Keywords

Root system, Plant morphology, Art, Plant drawings.
Apparato radicale, Morfologia delle piante, Arte, Disegni vegetali.

Received: *July 2023* / Accepted: *January 2024* DOI: 10.36253/rv-15773

Drawings by Erwin Lichtenegger

Erwin Lichtenegger (1928 – 2004) was born on 8 May 1928 as the 10th child on a mountain farm in Lavanttal (Carinthia) at an altitude of about 1000 m. Agriculture and nature observation were his constant companions from childhood on. He attended an agricultural college and later studied agriculture at the University of Natural Resources and Life Sciences in Vienna (BOKU).

He carried out his first root excavations as a research assistant at the Phytosociological Institute of Prof. Dr Lore Kutschera. As part of the phytocenological mapping of the Keutschach valley, it seemed necessary to study root penetration in order to find out why species from dry and wet sites can grow so close together. At the time, there was little data available on the root penetration of different species. This was the motivation to start our own research. The first excavations showed the importance of root extension in the soil, both in depth and in the surrounding area. Prof. Kutschera quickly realized that Erwin Lichtenegger had a talent for exact drawing and analyzing root systems. Drawings seemed to be the best way to compare different species under natural site conditions. Winter wheat proved to be a good example of optimal root growth when sown at the right time. Sufficient root growth before the onset of winter allows deep rooting in frost-free soil zones even during the winter. This promotes efficient growth in the spring, resulting in good yields.

Cooperation with agriculture and forestry, water regulation and landscape protection are of great importance. The knowledge of rooting of natural species and breeding forms leads to a better assessment of the growth potential of crops. Roots help to build up the soil, protect it against erosion and help also to repair the damage in soil structure. They are good test organs to determine the effect of fertilizers, manure, as well as poisonous substances brought by air and soil as a result of environmental pollution. The vast field of agroforestry is the best example of how agriculture and forestry can work together to protect nature.

Plants from the various biocenoses were excavated from undisturbed ground by unearthing the roots under dry conditions with various digging tools such as cramps, ice picks, shovels and dissecting needles. Prior to altering their original position, scale drawings of root sections were made at periodic intervals during the excavation. This is the only method that represents the spatial expansion of plant root systems. Such a presentation is one of the most important prerequisites for the ecological interpretation of radication conditions. Excavations sometimes required holes two to four meters deep. The excavator

was only used occasionally to dig for tree roots. The deepest roots were found 6, 3 and 10 meters deep in a slope.

During the last 50 years, roots of about 1.000 species from 116 different plant families have been excavated and drawn. Investigations of various arable crops, greenland plants, field vegetables, shrubs and trees have been carried out at different sites in Carinthia, Austria and Central Europe, from the valley to the mountains, even in extreme locations such as the Gobi Desert, the Namib Desert, the Kalahari, in the Caucasus, Argentina and Australia. The root drawings are published in various books, presented in a separate list.

The 1.000 investigated species are published in Wurzelatlas which are the results of the different researches held by Erwin Lichtenegger through decades. In Wurzelatlas, 1982 and 1992, different species are ordered after the botanical families and great differences between these groups are clear to see, furthermore you see information about the root systems, where they grow, their agriculture use, the importance of landscape and soil protection and also the soil types and soil kinds.

Wurzelatlas 1982 (Volume 1: Monocotyledoneae) describes the root systems of monocotyledonous plants in Central Europe. Each species is explained in detail, including information about their shape, where they grow, and their use in agriculture. The book also has drawings that show what the roots look like. The species are organized into groups based on their plant families.

Wurzelatlas 1992 (Volume 2: Dicotyledoneae) focuses on the root systems of dicotyledonous plants in Central Europe, the grouping is again (the botanical families, like the Wurzelatlas 198). Similar to the first book, it describes different species and includes drawings of their roots from different places and similar places. It also features plants from other countries and covers both wet and dry environments.

The Wurzelatlas 1997 takes a different approach by grouping species based on their growing conditions. It includes many foreign plants. In the book from 1997 you find the individual species classified according the according to related site conditions as dry, or semidry, wet or very wet conditions. These differences give possibilities to different views. By comparing grasses, herbaceous, or woody plants in similar locations it was possible to identify regularities that allowed certain similarities to be found through the spread of roots in the soil. Species from similar growing places are placed together. For example, grasses in cooler areas are characterized by a preferred root spread in the upper soil layers and grasses in warmer areas by particular deep roots, for this reason the complete title of the Wurzelatlas 1997 is *Bewurzelung von Pflanzen verschiedener Lebensräume* (The rooting of plants in different habitats).

For all specie drawings are shown, sometimes more than only one. The description has morphological, geographic dates and agricultural connections. The species are ordered after the botanical families. Overall, the Wurzelatlas are a valuable resource for exploring what lies beneath the ground!

The depth and lateral extent of the roots in the different horizons is one of the most important data obtained from excavating the various plants.

Different root types

The spatial variability of plant root systems can be influenced by the growth of the plants, the climate and soil conditions within the species' hereditarily fixed blueprint.

Root types of plants with a pole or taproot system reach the greatest root depth, if the ground is warm and moist. For example, *Taraxacum serotinum* (Kutschera & Lichtenegger 1992, fig. 340), a ratio of plant height to root depth was found to be 13 cm/456 cm. This plant grew on a steep slope with Loess at the Pannonian region near Vienna. Root depth is not only an indicator of climate and soil conditions, but is also important for draught tolerance, slope stability,

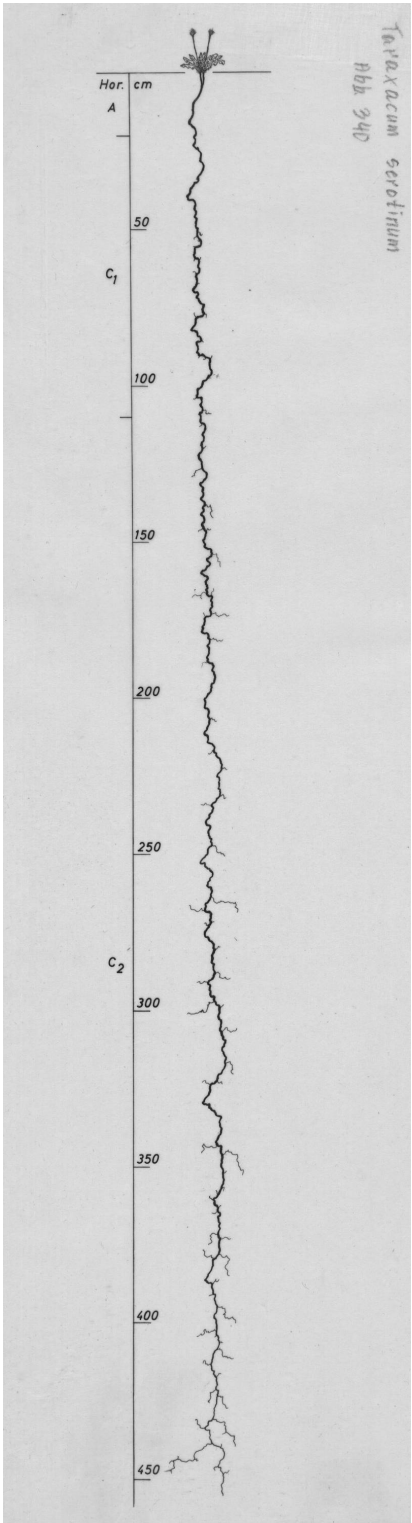

Fig. 1 - *Taraxacum serotinum*, Wurzelatlas mitteleuropaeischer Gruenlandpflanzen, Band 2/1: Pteridophyta und Dicotyledoneae, Lichtenegger, E. (Erwin) (Wurzeldarstellungen), 1992, Material/technique: calque, pentekening, pen drawing, format drawing 50x14 cm, fig. 340. H plant 13 cm, D root 456 cm, diameter root system cm.

soil fertility and last but not least the carbon stored in soil. The young development of most trees such as conifers and deciduous trees form a typical pole root. A clear poleroot can also be seen in *Castanea sativa* (Fig. 94, Wurzelatlas Kutschera & Lichtenegger 2002) with the strongly pre-growing poleroot down to a depth of 315 cm. A lush lateral root formation can be seen near Flur. The pole root of *Fagus sylvatica* is very clear in the young plants in Fig. 101 to find and very difficult to recognize in the adult trees. In *Pinus sylvestris*, the pole root is clearly recognizable. *Arctostphylos alpinus* (Kutschera & Lichtenegger 1997, fig. 109) a creeping dwarf shrub has a distinct pole root. It grows predominantly close to the ground. The maximum depth of growth is 30 cm. The pole root length could be found up to a 150 cm. In *Genista germanica* (Kutschera & Lichtenegger 1992, fig. 120), a pole-rooted semi-shrub, the pole root is clearly visible and reaches a depth of 90 cm. The spatial spread is cylindrical in the upper part and inverted conical in the lower part. *Calluna vulgaris*, a pole-root dwarf shrub in a semi-arid grassland near Klagenfurt (Kutschera & Lichtenegger 1992, figg. 85-86) or a shoot-root dwarf shrub in the Lüneburg Heath.

Root types of shoot root plants include almost all species of monocotyledons. Examples as *Carex humilis* with a cylindrical (Kutschera & Lichtenegger, 1982, fig. 70,) and *Lolium multiflorum* (Kutschera, 1960, fig. 45) with a predominantly obconical root system show reference to more arid and significantly more humid growth conditions.

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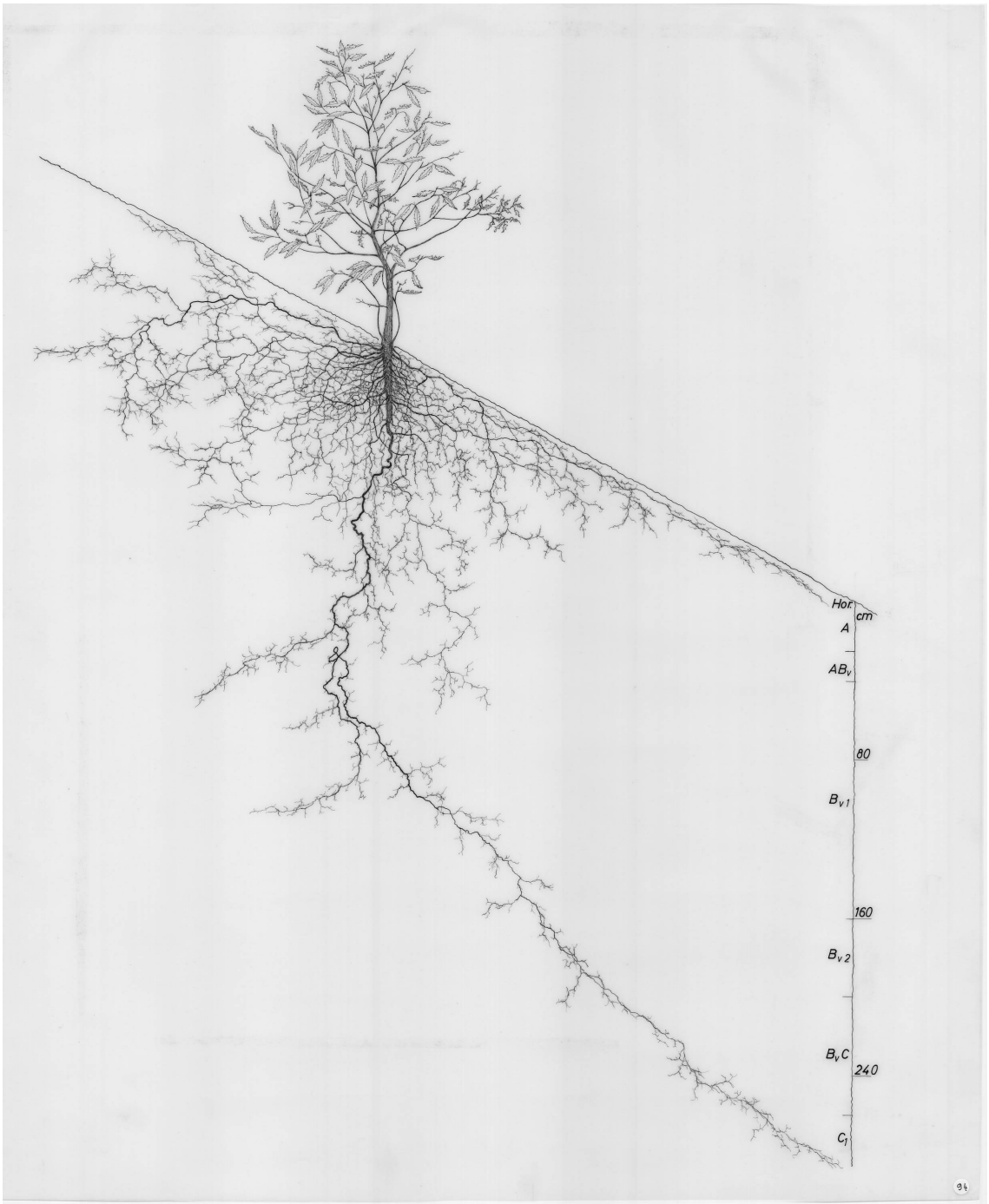


Fig. 2 - *Castanea sativa*, Wurzelatlas mitteleuropäischer Waldbäume und Sträucher, Kutschera, L.; Lichtenegger, E. (Wurzeldarstellungen), 2002, Material/technique: calque, pentekening, pen drawing, Format drawing 61 x 50 cm, fig. 94. Excavated plant: H plant 123 cm, D root 235 cm, diameter root system 315 cm.

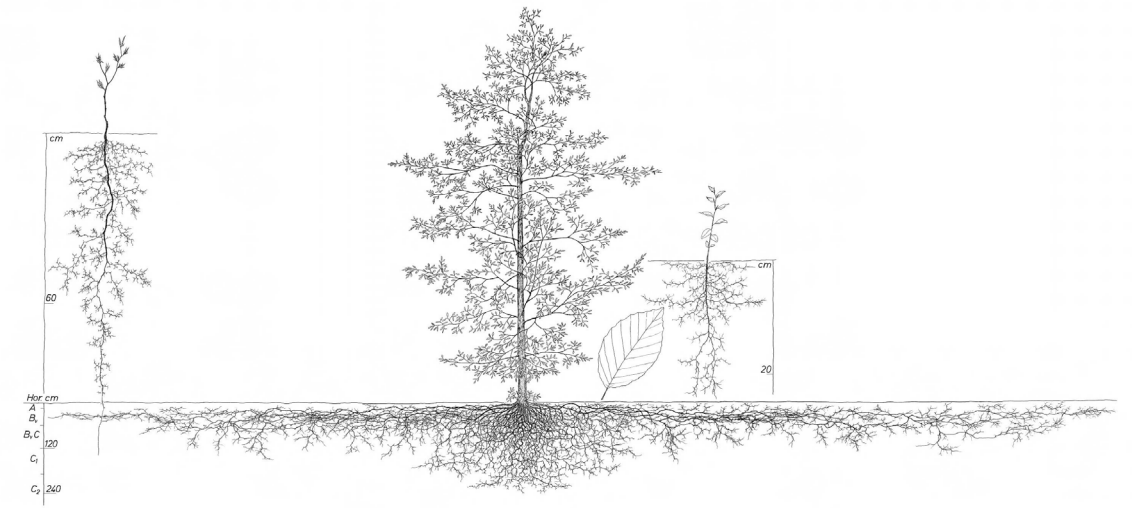


Fig. 3 - *Fagus sylvatica,* Wurzelatlas mitteleuropäischer Waldbäume und Sträucher, Kutschera, L.; Lichtenegger, E. (Wurzeldarstellungen), 2002, Material/technique: calque, pentekening, pen drawing, Format drawing 52x99 cm, fig. 101. Excavated plant: H plant 1040 cm, D root 240 cm, diameter root system 2820 cm.

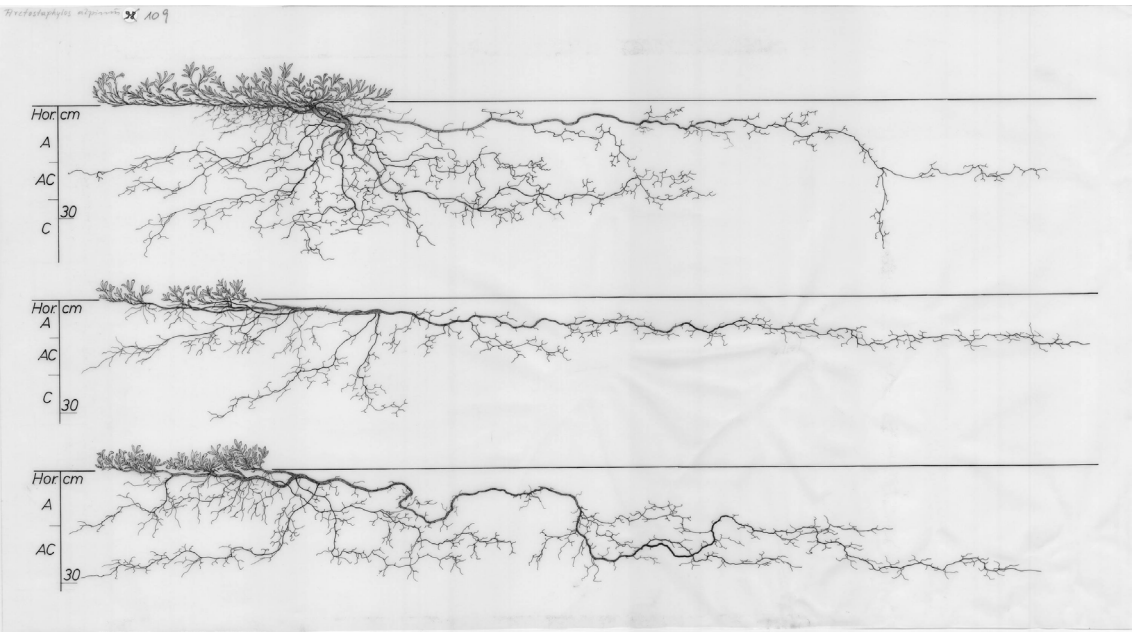


Fig. 4 - *Arctostaphilus alpinus*, Bewurzelung von Pflanzen in verschiedenen Lebensräumen (Stapfia 49), Lichtenegger, E. (Wurzeldarstellungen), 1997, Material/technique: calque, pentekening, pen drawing, Format drawing 34 x 61 cm, fig. 109.

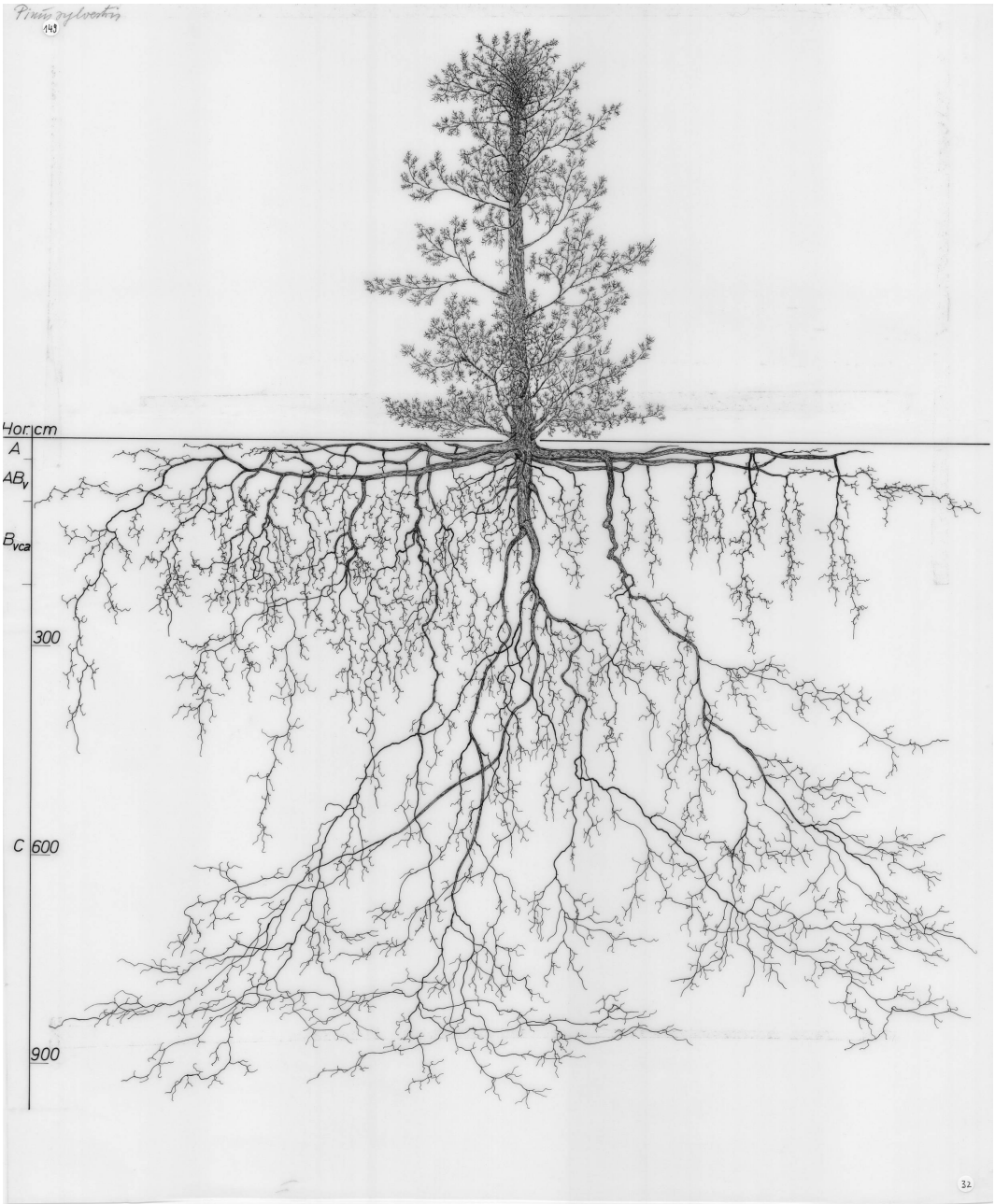


Fig. 5 - *Pinus sylvestris*, Wurzelatlas mitteleuropäischer Waldbäume und Sträucher, Kutschera L.; Lichtenegger E. (Wurzeldarstellungen), 2002, Material/technique: calque, pentekening, pen drawing, Format drawing 58 x 48 cm. Excavated plant: H plant 575 cm, D root 950 cm, diameter root system 1380 cm

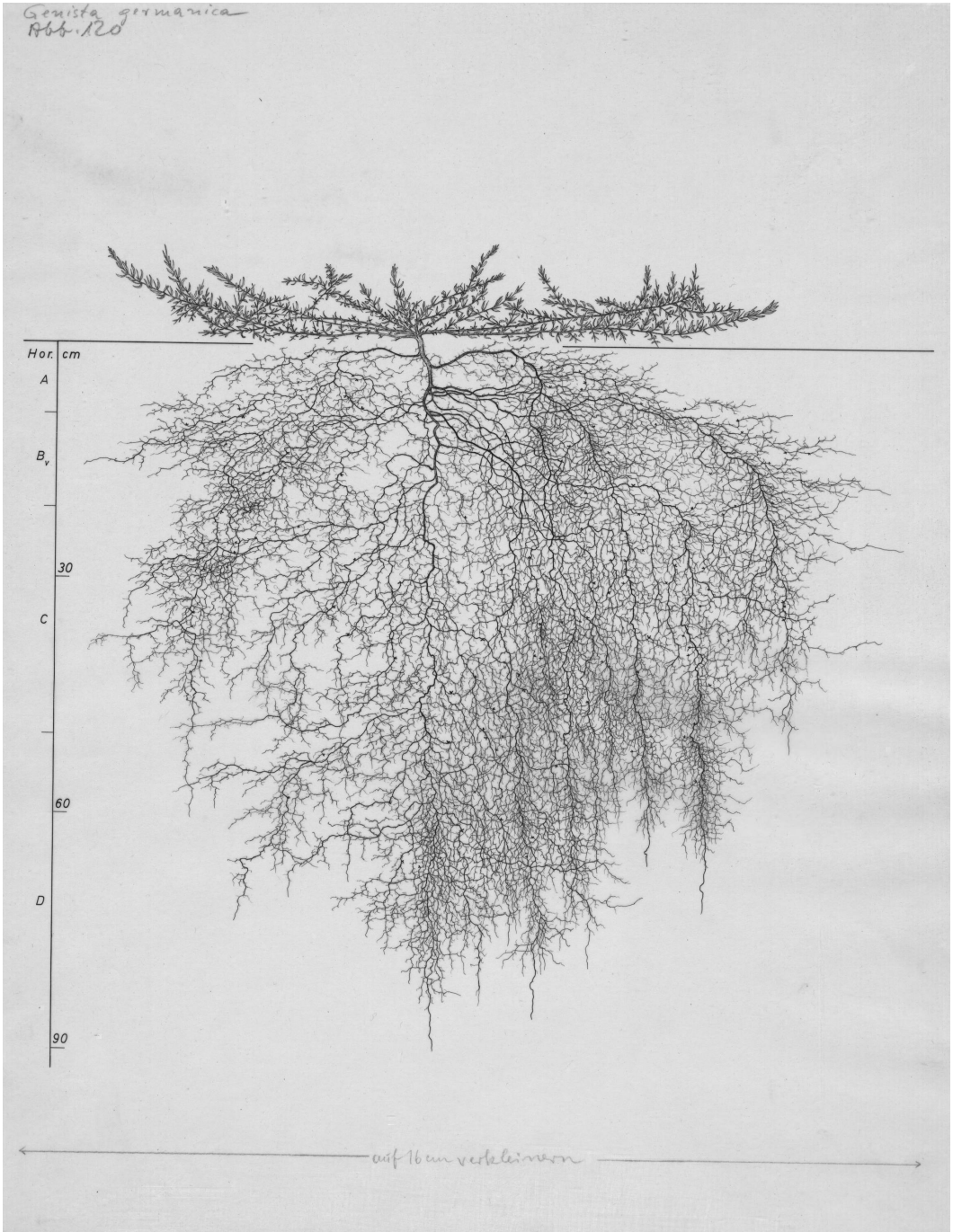
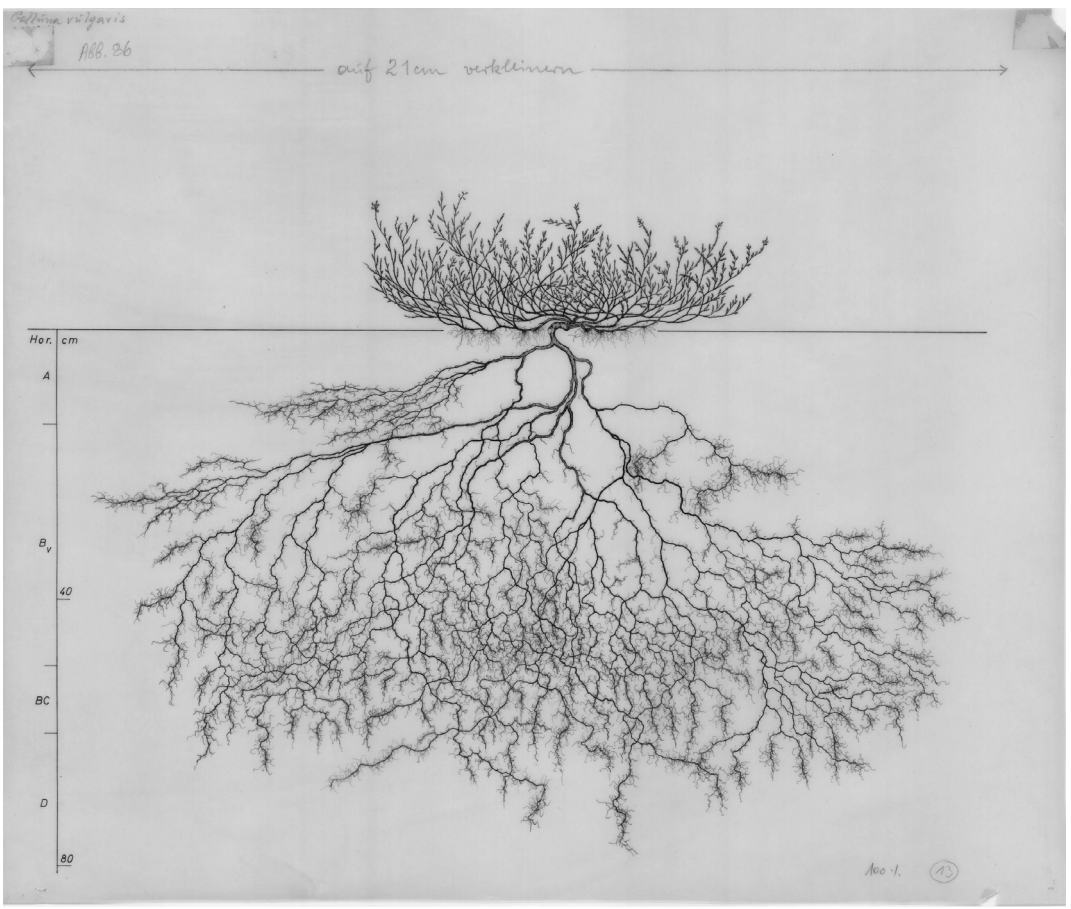
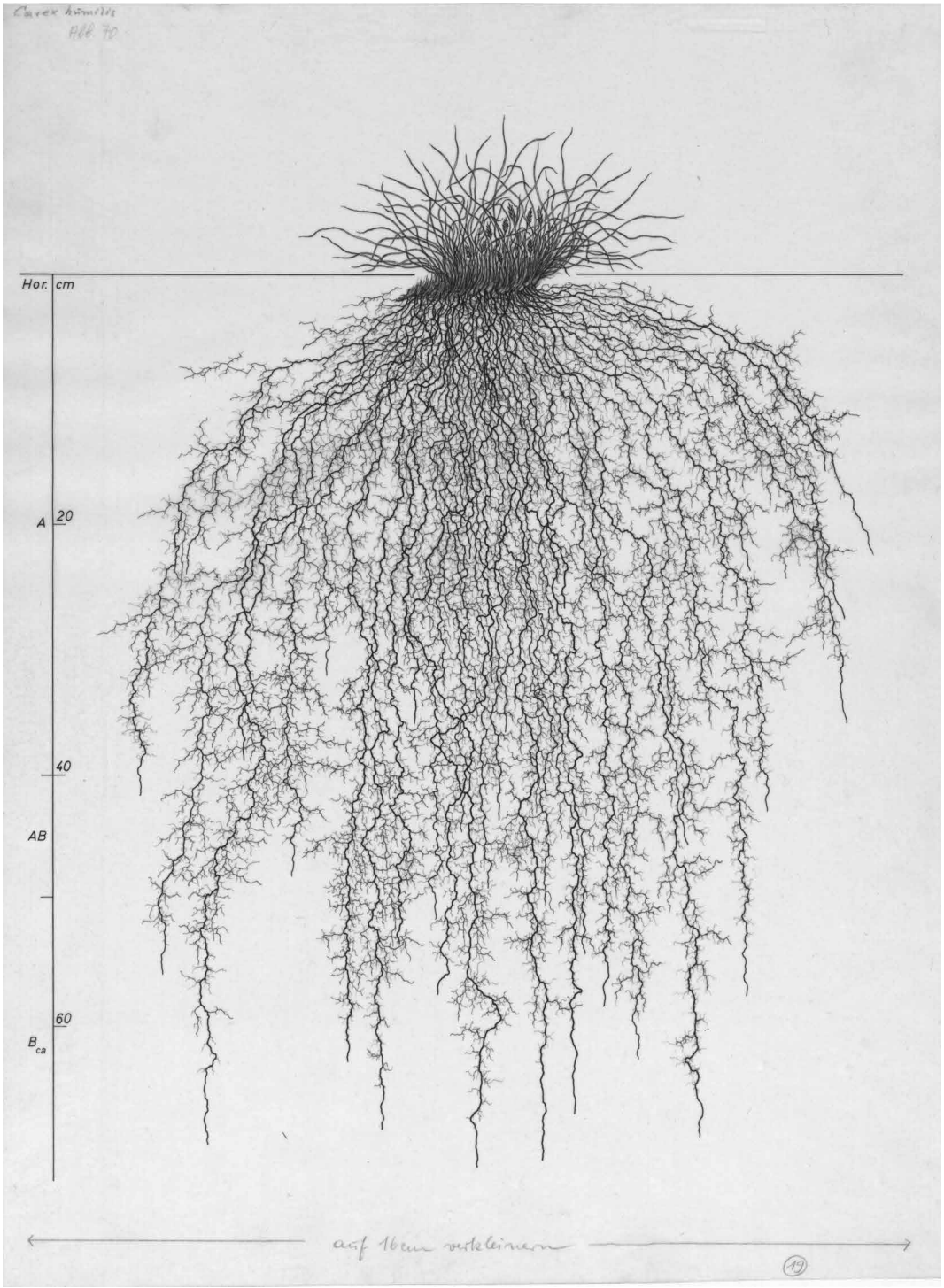


Fig. 6 - *Genista germanica*, Wurzelatlas mitteleuropaeischer Gruenlandpflanzen, Band 2/1: Pteridophyta und Dicotyledoneae, Lichtenegger, E. (Wurzeldarstellungen), 1992, Material/technique: calque, pentekening, pen drawing, format drawing 52x42 cm, fig. 120. Excavated plant: H plant 14 cm, D root 90 cm, diameter root system 104 cm.

Fig. 7 - *Calluna vulgaris*, Wurzelatlas mitteleuropaeischer Gruenlandpflanzen, Band 2/1: Pteridophyta und Dicotyledoneae, Band 2/1: Pteridophyta und Dicotyledoneae, Lichtenegger, E. (Wurzeldarstellungen), 1992, Material/technique calque, pentekening, pen drawing, format drawing 34x41 cm, fig.86. Excavated plant: H plant 20 cm, D root 78 cm, diameter root system 129 cm.

Fig. 8 - *Carex humilis*, Wurzelatlas mitteleuropaeischer Gruenlandpflanzen, Band 1: Monocotyledoneae, Lichtenegger, E. (Wurzeldarstellungen), 1982, Material/technique calque, pentekening, pen drawing, Format drawing 52x38 cm, fig.70. Excavated plant: H plant 13 cm, D root 72 cm, diameter root system 62 cm.




Carex humilis
Abb. 70
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17

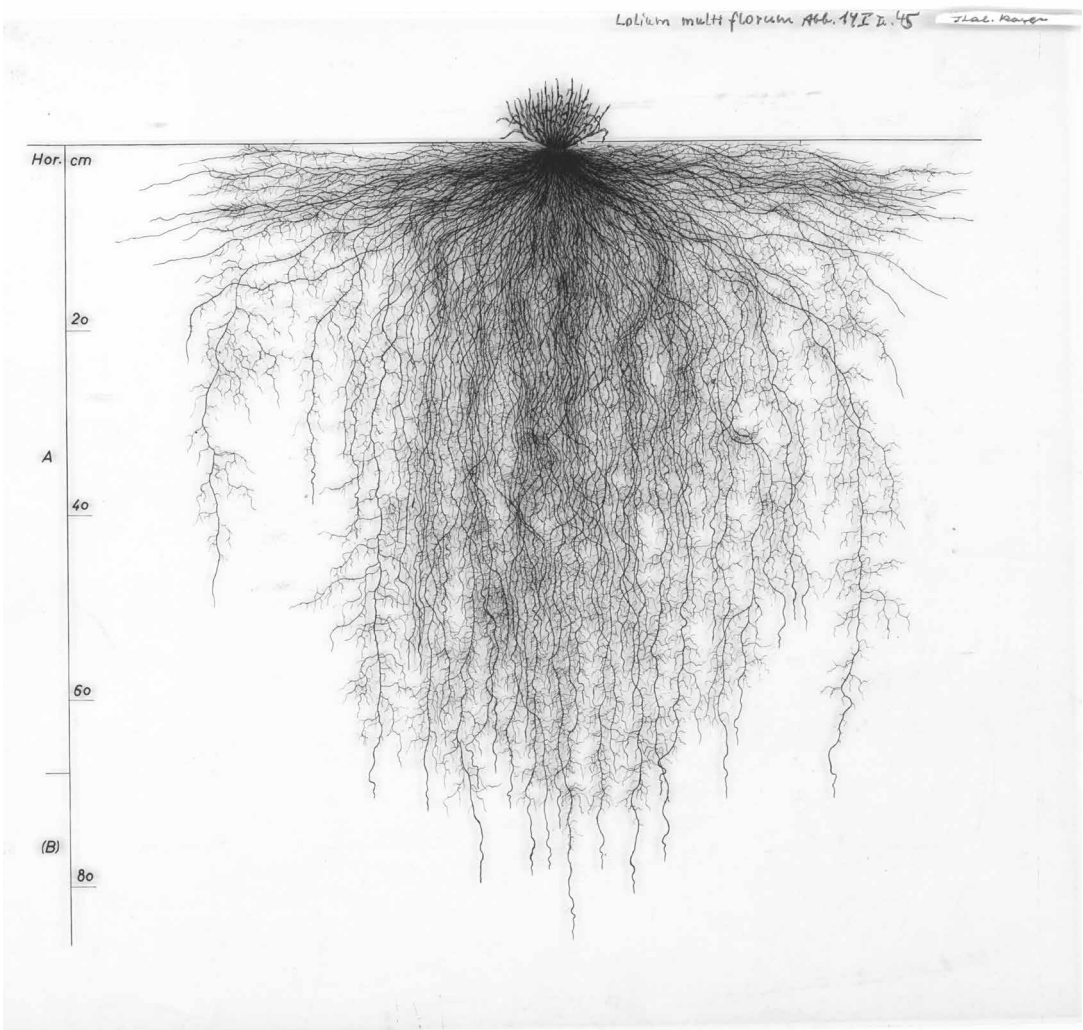

Fig. 9 - *Lolium multiflorum*, Wurzelatlas: mitteleuropaeischer Ackerunkraeuter und Kulturpflanzen, Lichtenegger, E. (Wurzeldarstellungen), 1960, Material/technique: calque, pentekening, pen drawing, format drawing 43x31cm, fig. 45. Excavated plant: H plant 60 cm, D root 86 cm, diameter root system 93 cm; im aehrenschieben; anfang juni.

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The drawings collection of the roots is, at the present, at the *Wageningen University.* (*https://images.wur.nl/digital/collection/coll13y).* This collection stores 1.000 drawings, the outcome of 50 years of root system excavations and drawings executed in Europe, predominantly Austria. The drawings, their analysis and description were executed by the Pflanzensoziologisches Institut, Klagenfurt, led by Prof. Dr. Lore Kutschera (d. 2008) and Prof. Erwin Lichtenegger (d. 2004).

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